Pile-up Backgrounds in Upstream ECAL
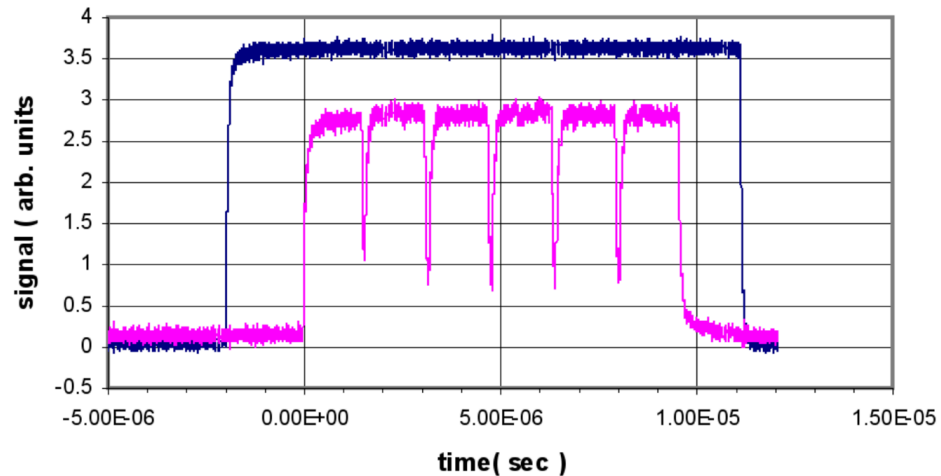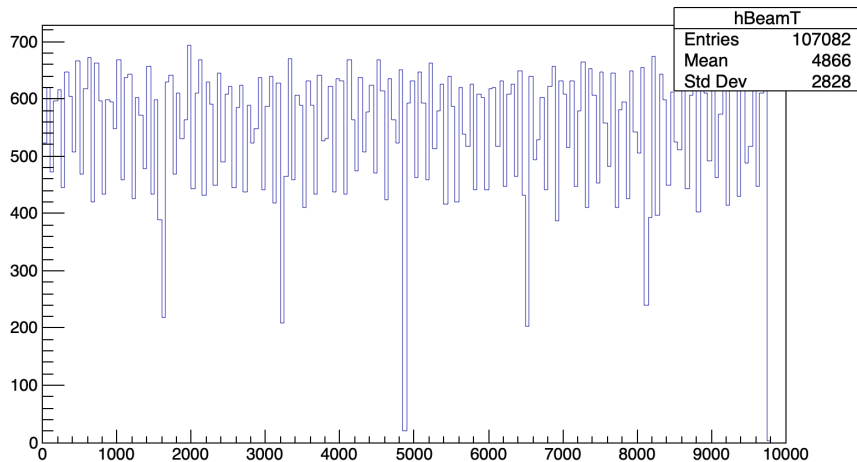
Summary of three independent studies
(Matteo Tenti, Artem Chukanov, Bing Guo)

Bing Guo

Mar 9th, 2021

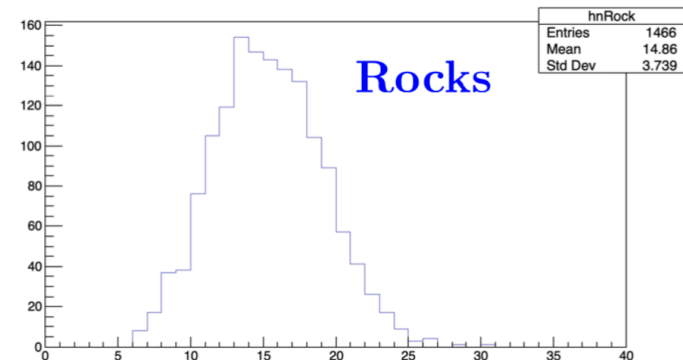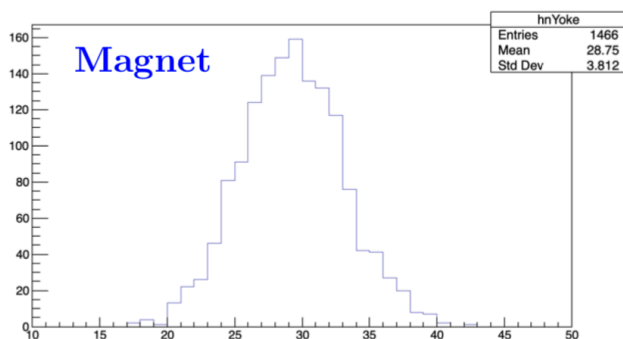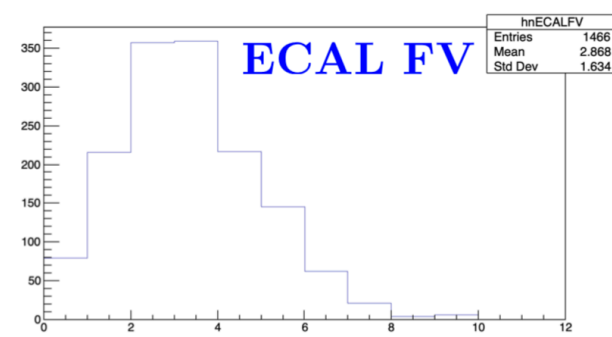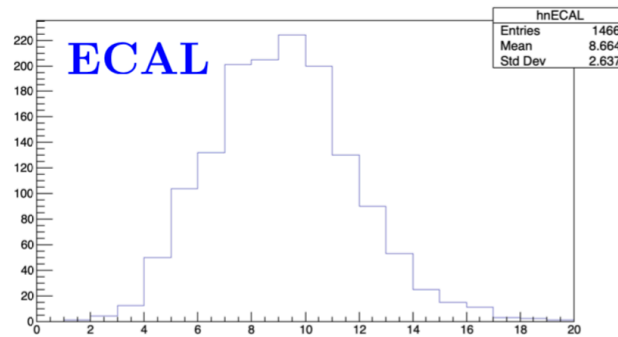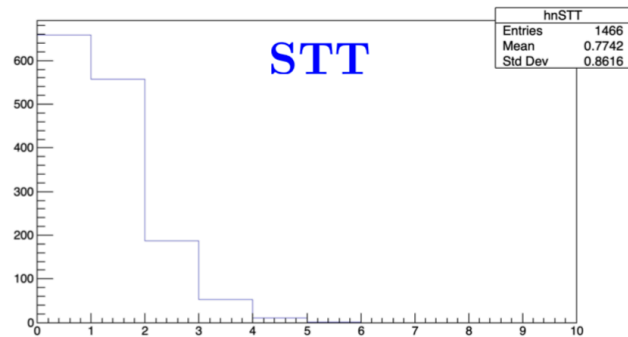# Beam simulation

- 9.6us per spill
- 6 batches, 84 bunches/batch
- nEmpty1Bunch=2
- 1 bunch: gaus, mean: 19ns rms: 1.5ns

- SAND events and rock events are generated separately. They are merged in later stage spill by spill.

Events hitting ECAL within a spill

- Require at least one reconstructable cell
  - Threshold: 2.5 npe
- Total number of events: 53/spill in FHC beam

Pileup

- Digitization based on sand-stt from github.
- The impact of pileup upon ECAL-FV events is evaluated.
  - Add all detected hits arriving within a fixed integration window from the earliest detected hit
  - Pileup event: hits from different events are summed together within same integration window
  - Focus on the upstream barrel ECAL
  - The impact of pileup evaluated with two different integration windows: 400ns and 30ns

One spill event display
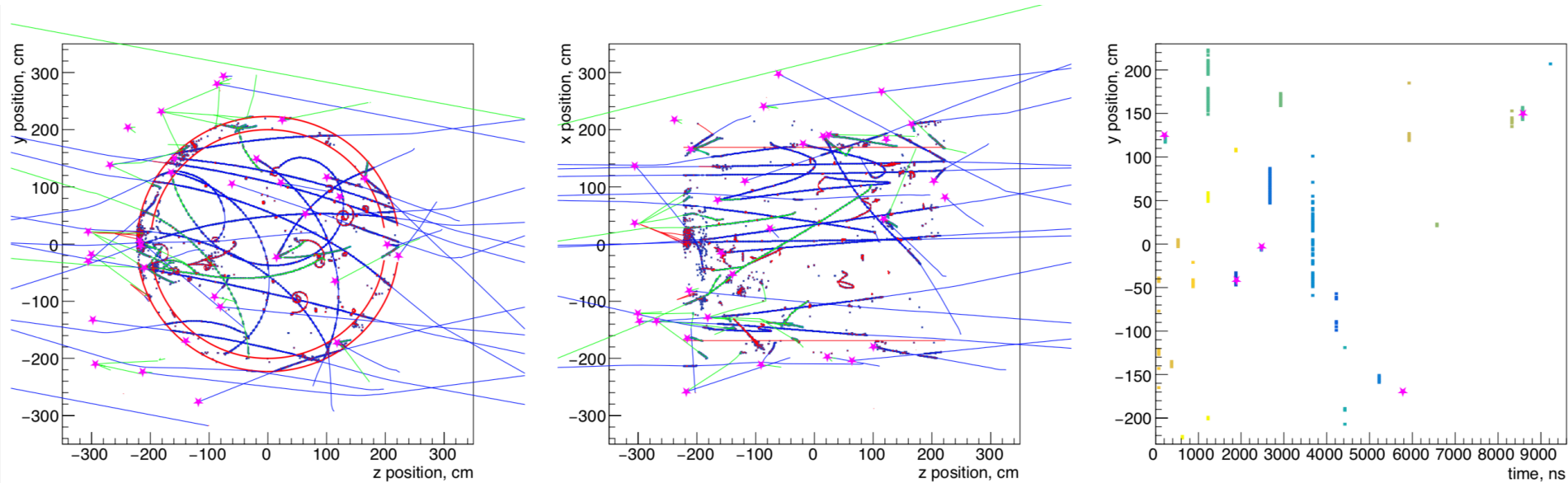
- Star: vertex, blue: muon track, green: non-muon tracks

- Each color represents an individual event

One spill event display
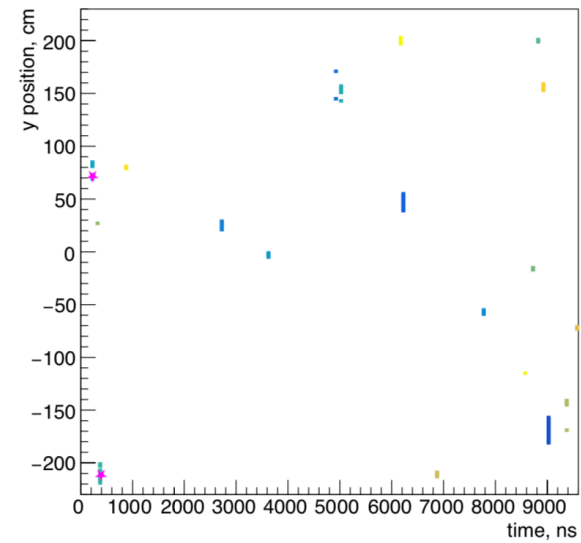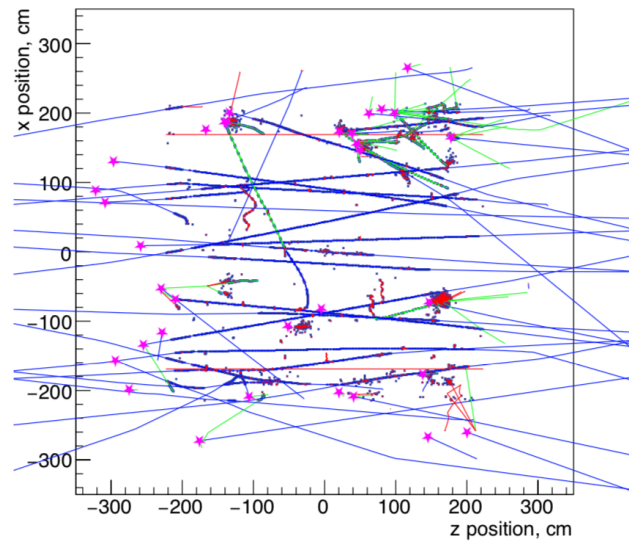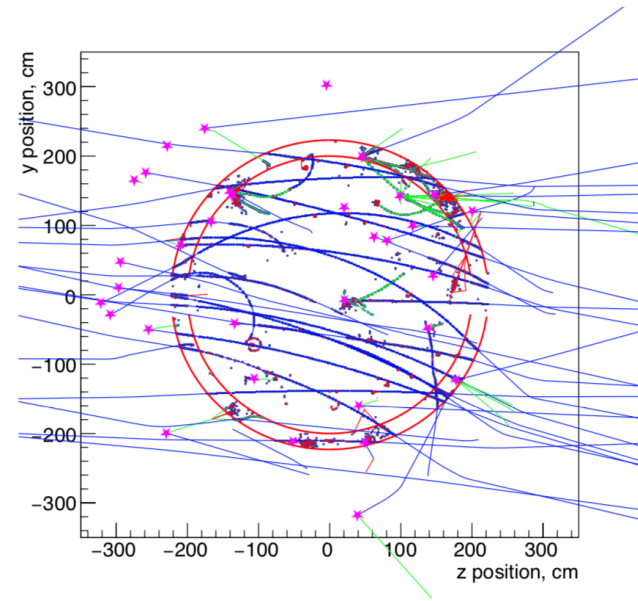
One spill event display
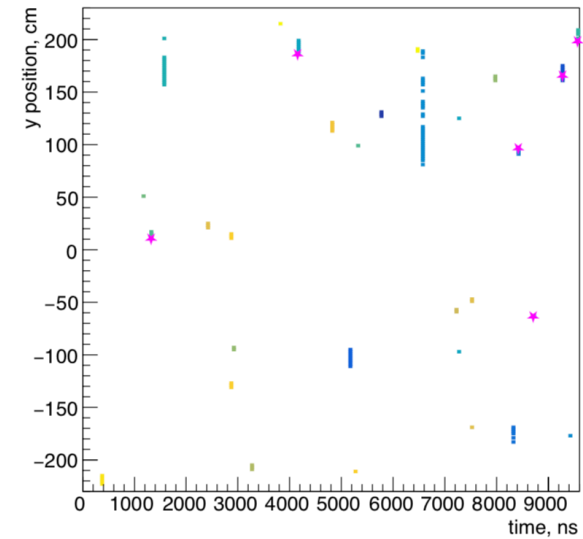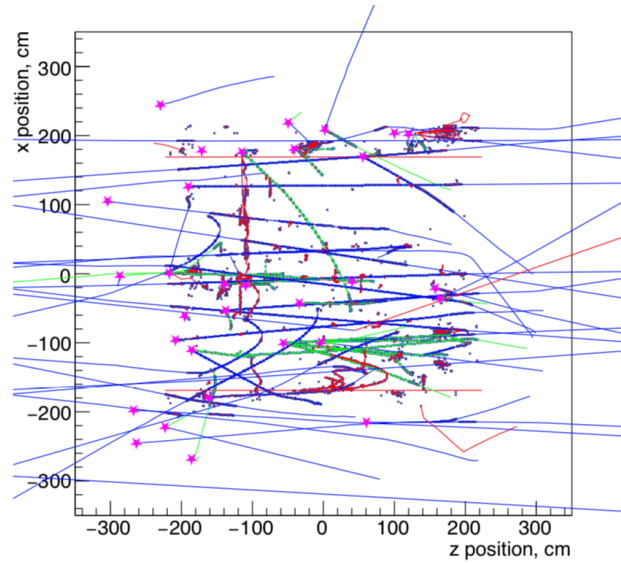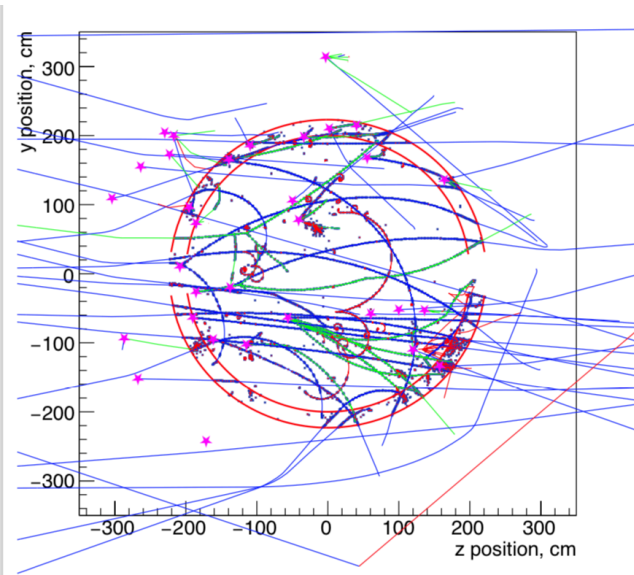
Signal events pileup

- Signal event:
  - CC event originated in the fiducial volume of the upstream barrel ECAL (front 11 modules, $|x|<1.69$ m)
- Fraction of signal events with at least one cell affected by pileup:
  - 19% for Integration window: 400ns
  - 2.6% for Integration window: 30ns
  - mostly small pileup from single cell

Impact of pileup with 400ns window

hnCell_overlap	
Entries	14143
Mean	0.6225
Std Dev	2.078

Number of pileup cells per event

htemp	
Entries	24213
Mean	19.85
Std Dev	15.82

Number of cells per event
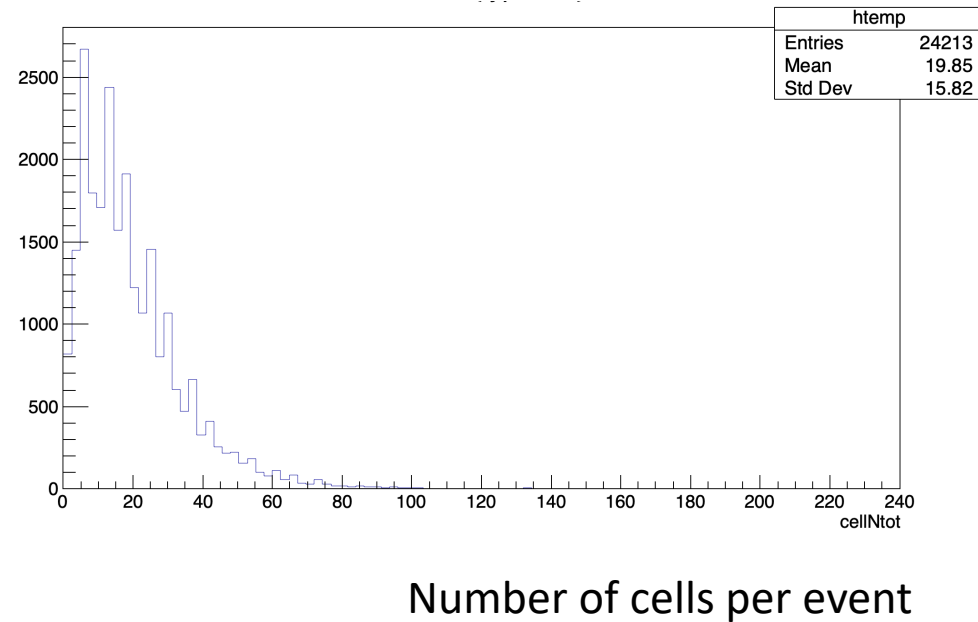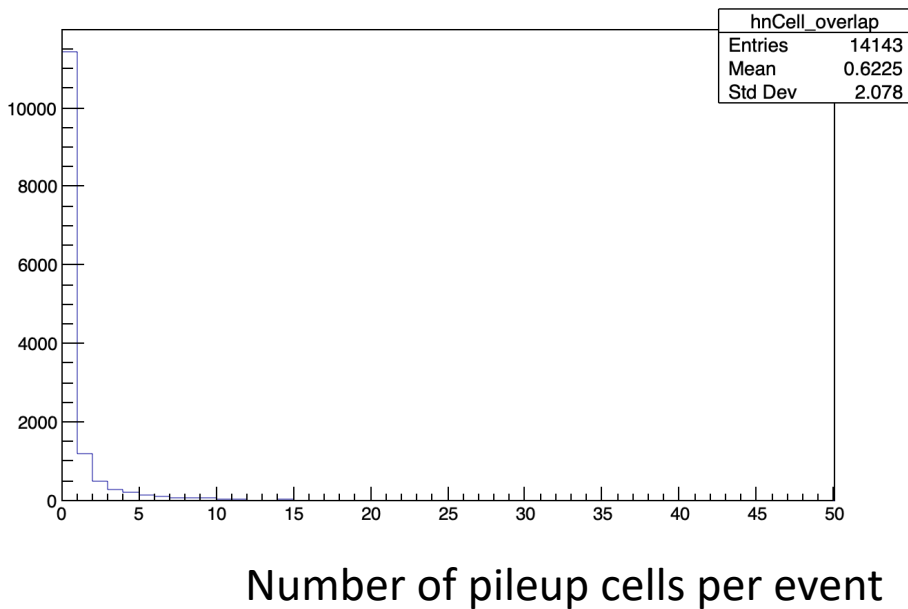
Average: 0.6 cell

Impact of pileup with 400ns window

Fraction of cells with pileup

Average: 1%
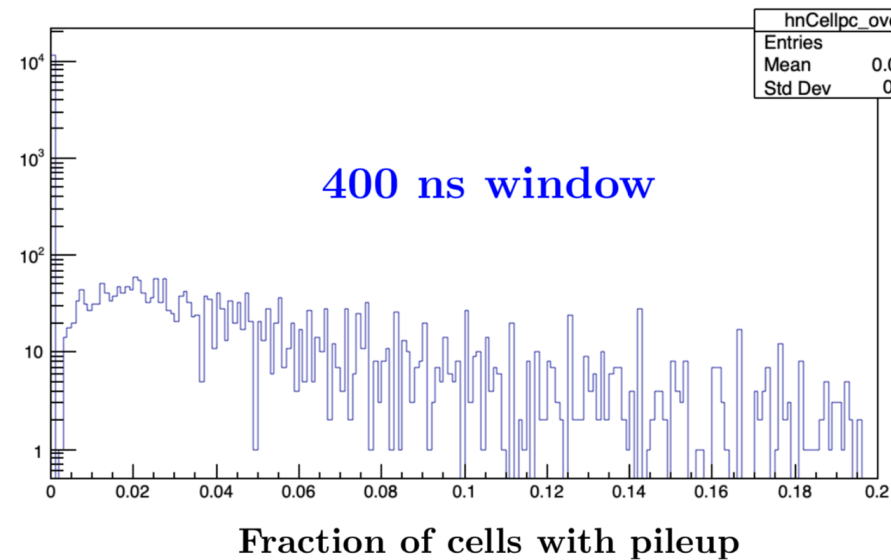
Fraction of pileup energy
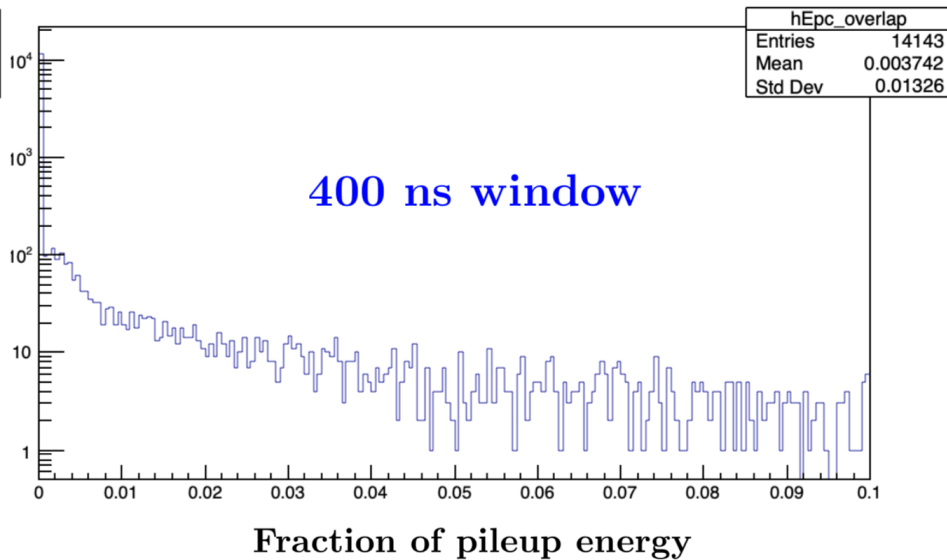
Average: 0.4%

Impact of pileup with 30ns window

hnCell_overlap	
Entries	14146
Mean	0.05726
Std Dev	0.4875

Number of pileup cells per event
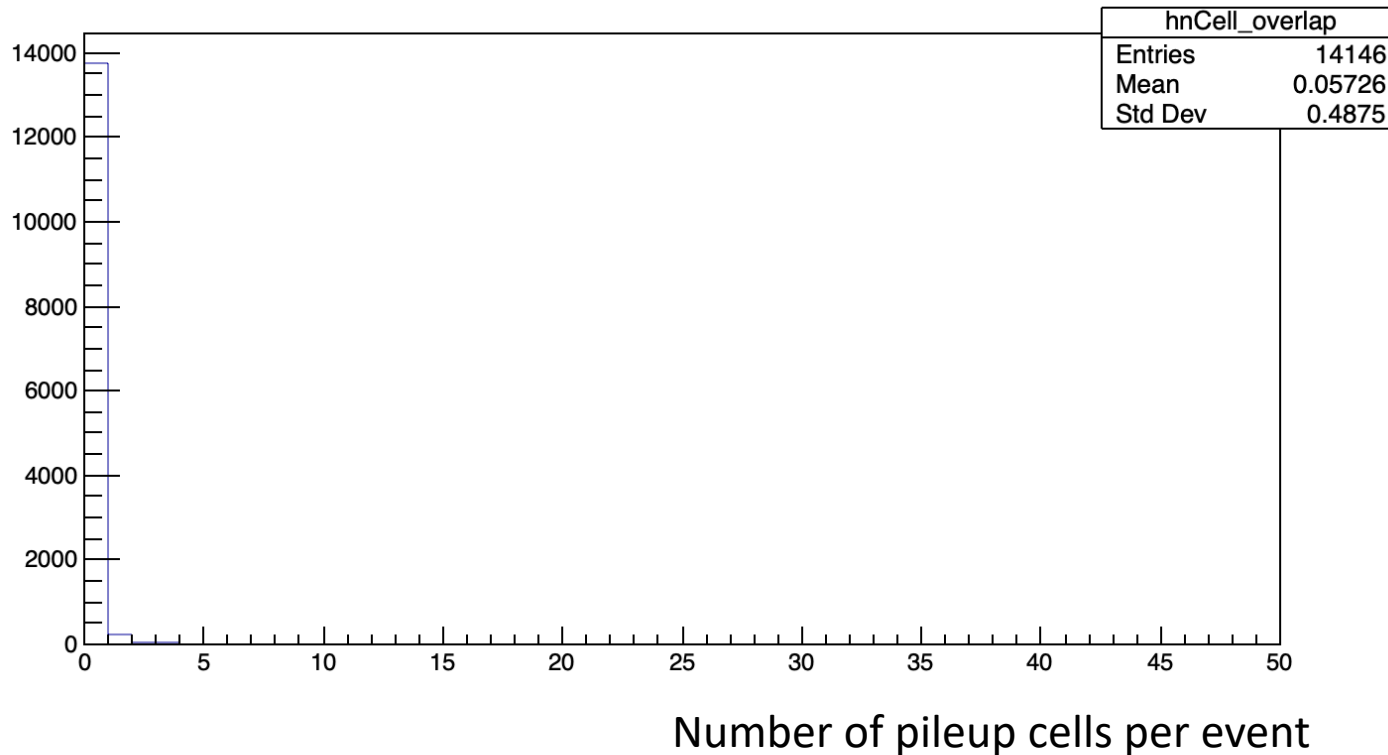
Average: 0.06 cell

Impact of pileup with 30ns window
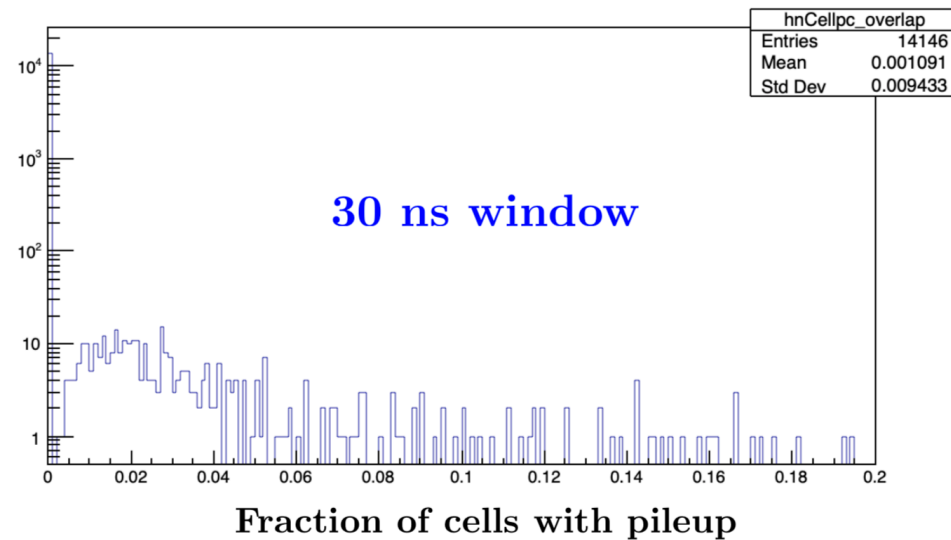
Average: 0.1%
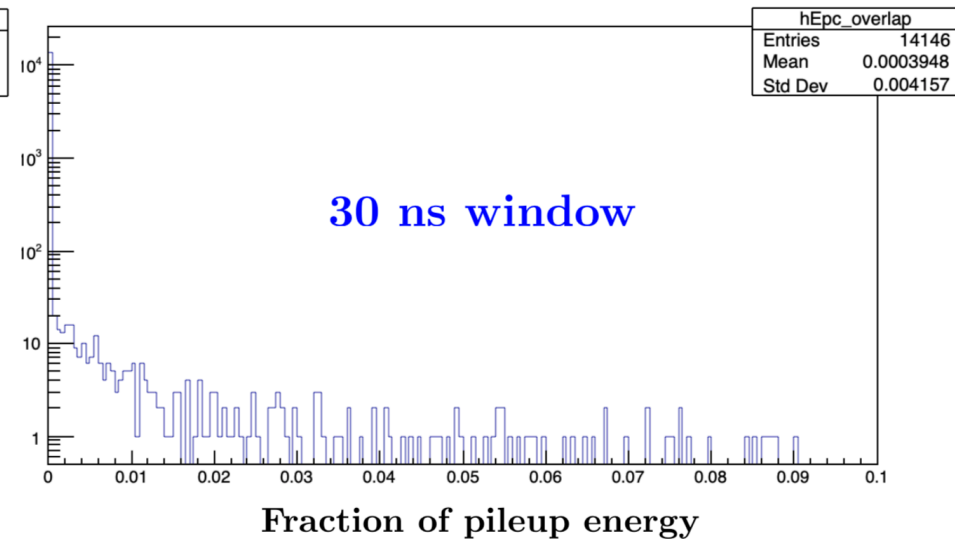
Average: 0.04%

Pileup sources

	μ	e	π	K	p	n	γ	others
Fraction of events with pileup	33.9%	1.6%	21.9%	1.0%	10.5%	19.8%	10.1%	1.4%
Fraction of cells with pileup	39.7%	1.0%	20.8%	0.9%	8.8%	17.8%	9.9%	1.2%

About 70% of pileup originate from charged particles

Identification of out-of-time tracks (pileup)

Example:

Two tracks reconstructed in STT, 1 from signal event, 1 from yoke which happen to cross signal ECAL cluster

earlyid:8401 2mufrom 1clu: extrapwe
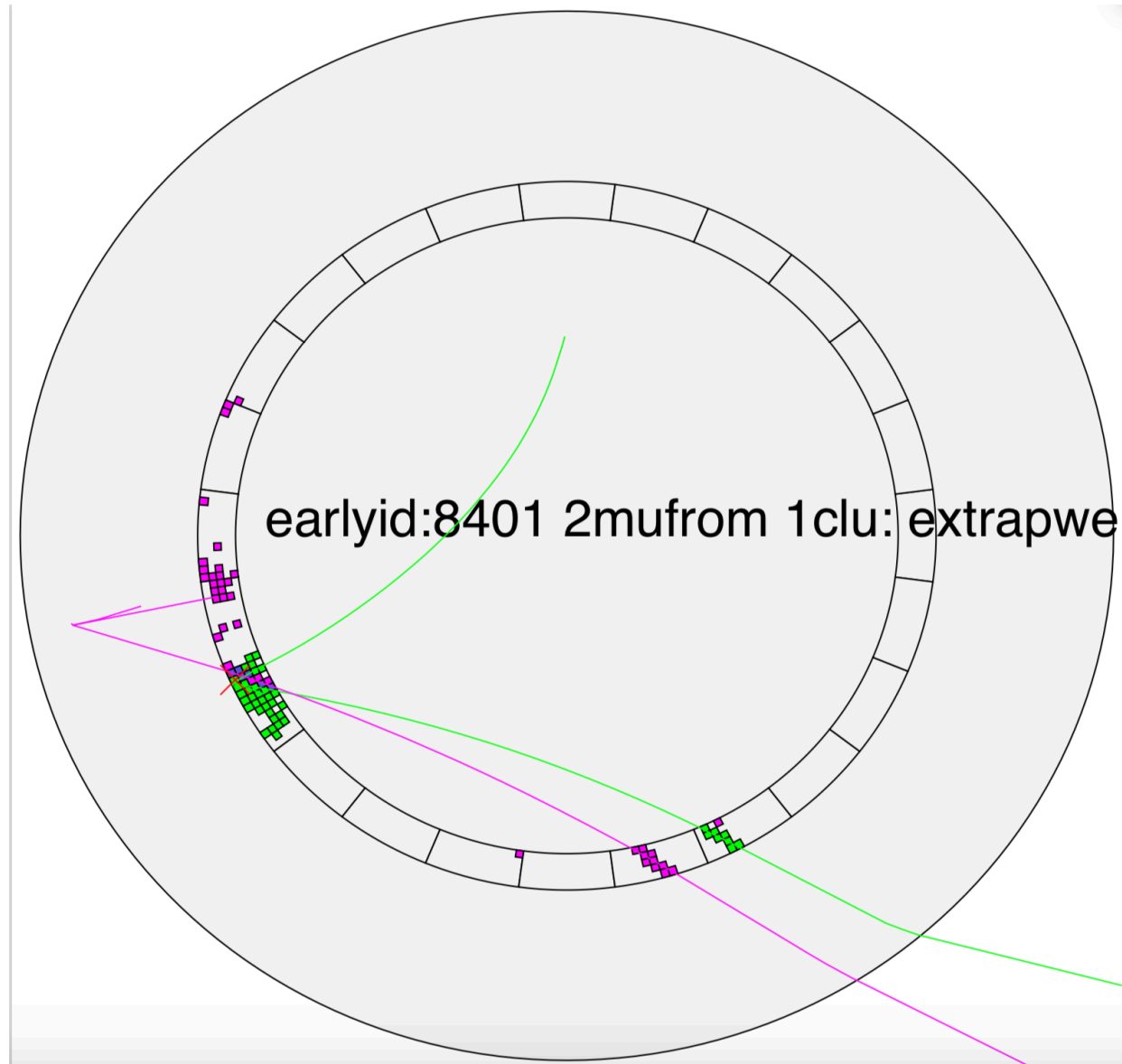
Identification of out-of-time tracks (pileup)

- Only consider STT reconstructable muons (n (Y) hit>=6)

- Smear muon by circular fitting

- Back extrapolating both muons to the ECAL cluster, calculate the time in ECAL cluster

- Comparing it with ECAL cluster average time

- fraction of events with >=2 primary tracks reconstructed in STT: 87%
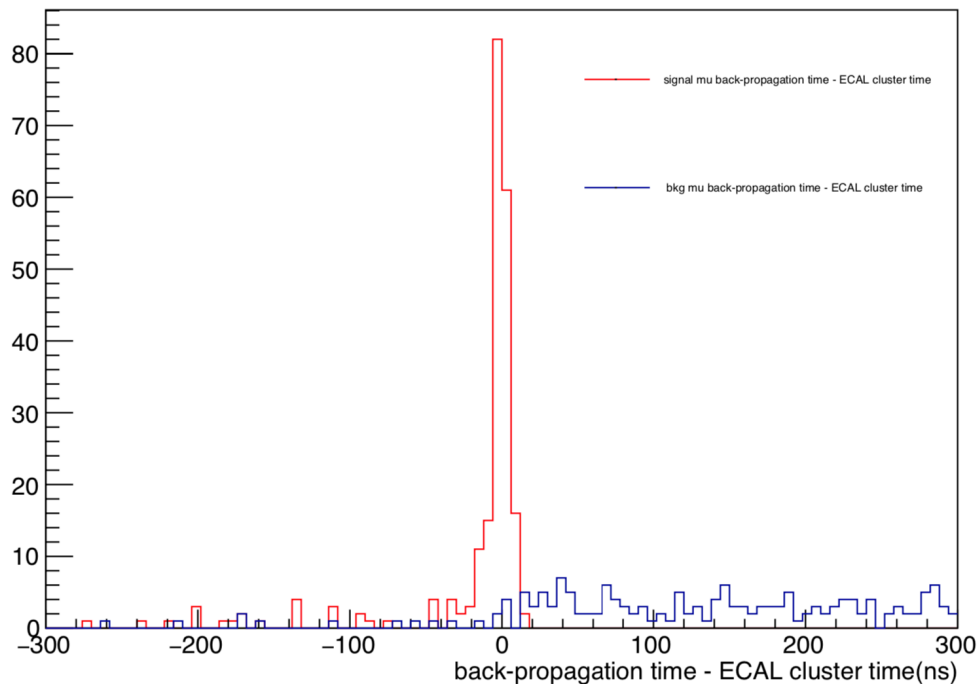
Summary

- Realistic simulations of the complete beam spill have been performed to study the pileup backgrounds in the upstream barrel ECAL

- The fraction of the CC events in the upstream barrel ECAL with pileup from different events within the spill was found to be 19% with 400ns window and 2.6% with 30ns window in the FHC beam

- The impact of pileup on the CC events in the upstream barrel ECAL was found extremely small:
    - it affects only 1% of the cells and 0.4% of the energy with 400 ns, dropping to 0.1% of the cells and 0.04% of the energy with 30ns in the FHC beam

- Charged tracks reconstructed in STT can be used to efficiently identify and subtract the corresponding pileup contributions.

- The pileup doesn't degrade the beam monitoring sensitivities in the ECAL plus STT configuration.